THERMOSTAT WITH ENERGY MODELING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 16/146,659, filed Sep. 28, 2018, which claims the benefit of and priority to U.S. Patent Application No. 62/595,757, filed Dec. 7, 2017, all of which are hereby incorporated herein by reference in their entireties.

BACKGROUND

[0002] A thermostat, in general, is a component of an HVAC control system. Thermostats sense the temperature or other parameters (e.g., humidity) of a system and control components of the HVAC system in order to maintain a set point for the temperature or other parameter. A thermostat may be designed to control a heating or cooling system or an air conditioner. Thermostats use a variety of sensors to measure temperature and other desired parameters of a system.

SUMMARY

[0003] One embodiment includes a method for determining energy savings of a thermostat. The method can include obtaining, by one or more processing circuits of the thermostat, first data indicating an actual length of time that building equipment operated to heat or cool a building space associated with the thermostat; identifying, by the one or more processing circuits of the thermostat, a thermal model representative of the building space and the building equipment; detecting, by the one or more processing circuits of the thermostat, occupancy in the building space, wherein the thermostat is configured to automatically transition the building equipment to a low energy mode when no users are detected in the building space; generating, by the one or more processing circuits of the thermostat and based on the thermal model and the occupancy of the building space, an estimated amount of time that the building equipment would operate to heat or cool the building space at a particular setpoint value, and displaying, via a user interface, a graph indicating one or more time periods where occupancy was detected in the building space, and indicating an amount of time saved by automatically transitioning the equipment to the low energy mode, wherein the amount of time saved is determined based on the difference between the actual length of time that the building equipment operated and the estimated amount of time.

[0004] Another embodiment includes a thermostat for a building space. The thermostat can include a processing circuit. The processing circuit can obtain first data indicating an actual length of time that building equipment is operated to heat or cool a building space associated with the thermostat; identify a thermal plant model representative of the building space and the building equipment; detect occupancy in the building space, wherein the thermostat is configured to automatically transition the building equipment to a low energy mode when the building space occupancy is below a threshold; generate, based on the thermal plant model and the occupancy of the building space, an estimated amount of time that the building equipment would operate to heat or cool the building space at a particular setpoint value; and display, via a user interface, a graph indicating one or more time periods where occupancy was detected in the building space, and indicating an amount of time saved by automatically transitioning the equipment to the low energy mode, wherein the amount of time saved is determined based on the difference between the actual length of time that the building equipment operated and the estimated amount of time.

[0005] Yet another embodiment includes a system for determining energy usage of a thermostat for a building space. The thermostat includes a processing circuit. The processing circuit can cause building equipment to operate to heat or cool the building space via one or more heating outputs or one or more cooling outputs, wherein an amount of time that the building equipment operates is recorded by the thermostat; detect, while the building equipment is operating, occupancy in the building space, wherein the thermostat is configured to automatically transition the building equipment to a low energy mode in response to the occupancy; generate a simulated runtime for the building equipment based on a thermal plant model, the simulated runtime indicate an estimate amount of time that the building equipment would operate to heat or cool the building space according to a setpoint, wherein the thermal plant model is a thermal model of the building space and the building equipment; and display, via a user interface, a graph indicating one or more time periods where occupancy was detected in the building space, and indicating an amount of time saved by automatically transitioning the equipment to the low energy mode, wherein the amount of time saved is determined based on the difference between the recorded length of time that the building equipment is operated and the simulated runtime.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Various objects, aspects, features, and advantages of the disclosure will become more apparent and better understood by referring to the detailed description taken in conjunction with the accompanying drawings, in which like reference characters identify corresponding elements throughout. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

[0007] FIG. **1**A is a drawing of a thermostat with a transparent cantilevered display, according to an exemplary embodiment.

[0008] FIG. **1**B is a schematic drawing of a building equipped with a residential heating and cooling system and a thermostat, according to an exemplary embodiment.

[0009] FIG. **2** is a schematic drawing of the thermostat and the residential heating and cooling system of FIG. **1**, according to an exemplary embodiment.

[0010] FIG. **3**A is a block diagram of the thermostat of FIGS. **1**A, **1**B, and **2** shown in greater detail, according to an exemplary embodiment.

[0011] FIG. **3**B is a block diagram of the thermostat of FIG. **3**A communicating with a remote device, according to an exemplary embodiment.

[0012] FIG. **4** is a block diagram the energy modeling features of the thermostat of FIG. **3**A, according to an exemplary embodiment.

[0013] FIG. **5** is a chart illustrating system identification that can be performed by the thermostat of FIG. **3**A, according to an exemplary embodiment.

[0014] FIG. **6** is a chart illustrating a plant simulation, according to an exemplary embodiment.